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Control of Tobacco Blue Mold (Downy Mildew) and Tobacco Flea Beetle

(A Progress Report in Two Parts)

1. Control of Tobacco Blue Mold (Downy Mildew)

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Introduction

Not since the outbreak of wildfire in 1918 and 1919 has a tobacco disease caused such widespread alarm among Virginia tobacco growers as the recent epidemics of blue mold. Since its appearance in Virginia in 1931, blue mold has been present to some extent each year. It caused extensive damage in 1932, 1933, and 1937, but the epidemic of 1937 was the most severe. The warm, dry springs of 1934, 1935, and 1936 were unfavorable for the development of blue mold and consequently very little damage resulted from the disease during those years. However, the history of blue mold in other countries together with its record during the past seven years in this country, indicates that this disease may continue to be a problem each year; and that during seasons favorable for its development, it may cause serious damage unless effective control measures can be applied.

For several years blue mold has been the subject of a concerted study by numerous research workers. The potential danger of the disease has stimulated research on its control, and practically every agricultural experiment station in the several tobacco-growing states in the United States is supporting such work. In most states the work is being sponsored cooperatively by the agricultural experiment stations and the United States Department of Agriculture. Duke University, in North Carolina, is also cooperating in these studies. So far, the various workers have pooled their results in order to hasten the solution of the problem; therefore, the credit for any progress of blue mold control that may result from these cooperative studies should go to the group of workers as a whole rather than to any particular individual.

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It should be stated at the outset that blue-mold control has not been worked out to the complete satisfaction of the research workers; nevertheless, it is felt that sufficient progress has been made in the development of control measures to warrant at least a progress report at this time. It should be clearly understood, too, that none of the control measures described herein are "foolproof"; all of them must be applied with care and precision. Furthermore, the chemical methods of control (spraying or fumigating) have not been tested over a sufficient number of years to determine whether or not they will control blue mold under all conditions. Therefore, definite recommendations must await the results of further experimental and demonstrational work with these methods.

Symptoms of Blue Mold

Blue-mold infection on small tobacco plants is first indicated by a downward curling of the leaves, followed in a day or two by the appearance of a grayish or bluish mildew on their lower surface. On larger plants, curling of the infected leaves is not particularly noticeable, but by the time the mildew appears on their lower surface, the affected areas begin to turn yellow. As the disease advances, the infected leaves gradually turn brown and die. The last stage of the disease is usually followed by bacterial infection which results in a soft rot of the affected leaves and a foul, fishy odor.

Blue mold develops rapidly and frequently spreads over the entire bed before the owner is aware of its presence. Once infection is established, the disease will remain active in the seed bed for a period of about ten days, after which the surviving plants generally recover rapidly. However, very small plants are usually killed outright. Plants that are set in the field from beds in which blue mold is still active or before the plants have had time to recover, usually die.

Cause of Blue Mold

Blue mold is caused by a fungus that belongs to a group of disease-producing micro-organisms which attack plants resulting in diseases commonly known as downy mildew. The blue-mold fungus grows through the tissues of the tobacco leaf and produces a mold-like growth on the underside. This mold-like growth consists of hair-like stalks on which are borne innumerable microscopic spores (seed of the fungus), which are so light in weight that they can be easily carried for long distances by the wind, and may thus be spread over wide areas. The spores that fall on tobacco leaves germinate readily in the presence of moisture when the temperature is low and infection is thus established. Although low temperature is more favorable for the development and spread of infection, the symptoms of the disease become more conspicuous on the plants on warm, sunny days following a cool, damp period, because the

infected plants dry out faster in hot weather. Diseases similar in appearance to blue mold are readily found on many other plants; but only tobacco, tomato, pepper, and eggplant are known to be attacked by tobacco blue mold.

Control of Blue Mold

In an attempt to develop a control of blue mold, research has been conducted along several different lines and as a consequence several different methods of control are now suggested for trial under practical field conditions. The methods described herein are termed (1) *the cultural method*, (2) *the fumigation method*, and (3) *the spray method*. The relative value of these methods in actual practice remains to be demonstrated.

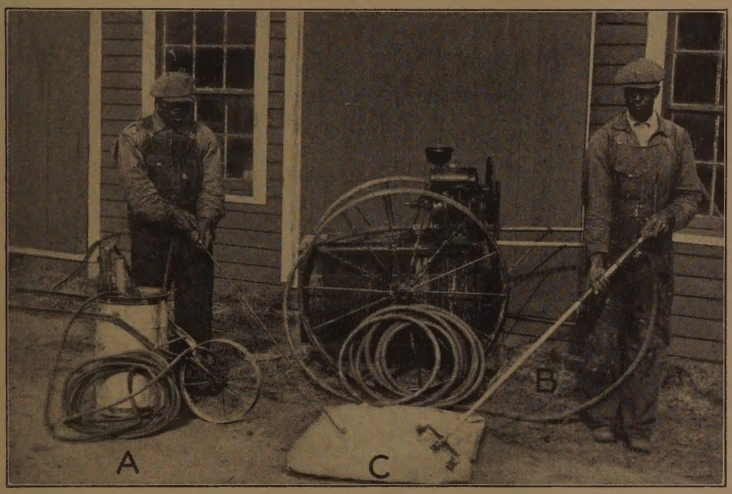

Figure 1.—Types of sprayers that may be used in spraying tobacco seed beds. A. Wheelbarrow sprayer that is pumped by hand. B. Small power sprayer that is ideal for spraying large seed beds. C. Types of rods and nozzles that should be used in spraying tobacco seedlings.

The cultural method.—This method of blue-mold control has been employed with some degree of success in Virginia and other states. The extra expense and labor involved in the use of this method is for the preparation of additional seed-bed space. The principal disadvantage to the method is that it does not prevent the development of blue mold in the seed bed and consequently when blue mold is severe there will be a delay of 10 to 15 days in transplanting, which may prove a detriment to the crop, especially if the most favorable seasons for setting plants are missed by such delay. The following practices come under the cultural method:

1. Locate seed beds on new sites in order to avoid infested soil that might serve as a source of early infection. There is evidence that an average of one-fourth to one-third of all seed beds sown on old sites are centers of early outbreaks of blue mold. The plants are small when infection develops under such conditions and as a result the damage is great. The larger the plants are at the time of an attack, the better chance they have to survive.

2. Locate the seed beds in places that will afford good soil drainage, good air drainage and sunshine during the entire day. Low, damp sites should be avoided, and trees that shade the seed bed should be removed in order that the plants may dry as rapidly as possible, after being wet by dew or rain.

3. Sow more seed-bed space than is ordinarily needed to set the crop. It is advisable to sow two to three times as much seed-bed space as would be needed in the absence of blue mold. The loss of plants from blue mold may range from 25 to 90 percent.

4. Prepare the seed-bed soil with special care and sow the seed early enough in the season to produce strong, thrifty plants before blue mold appears.

5. Remove the seed-bed covers during the day to allow direct sunlight to reach the plants, beginning about three weeks prior to transplanting. This procedure toughens the plants and makes them less susceptible to injury from blue mold. It may, however, expose the plants to damage by flea beetles, unless an insecticide is applied for their control.

6. Extravagant claims have been made for the practice of using certain brands of fertilizer as a control for blue mold but there are no experimental results to support such claims. However, there is evidence that moderate and judicious applications of nitrate of soda as a top dressing will materially aid diseased plants to recover. Some growers, though, by haphazard methods of applying nitrate of soda have not only failed to derive beneficial results but have injured their plants. In some sections of Virginia, in 1937, it was estimated that the damage from the careless applications of nitrate of soda was greater than that caused by blue mold.

When top-dressing applications are to be made, the exact amount of material to be used should be carefully weighed and not merely estimated. Not more than 4 or 5 pounds of nitrate of soda to each 100 square yards of seed-bed area should be used in a single application. If necessary, a second application may be made 8 or 10 days later. Of the several methods employed in applying the nitrate of soda, the most satisfactory procedure is to broadcast the dry material over the bed and then apply water to dissolve the nitrate of soda and wash it into the soil. If the nitrate of soda is not thoroughly washed off of the plants, serious burning will result.

The practices outlined under the cultural method of control are worth while even if blue mold should not prove to be an important factor, or even if spraying or fumigating for blue-mold control is anticipated. During seasons when blue mold is not very severe, cultural practices alone should prove satisfactory in providing enough good plants to set the crop; but if a severe epidemic of blue mold occurs, these practices will no doubt prove as disappointing as they did in 1937.

The spray method.—Of the many spray materials tested for blue-mold control, the one consisting of a mixture of cuprous oxide, Lethane spreader, cottonseed oil, and water is the most satisfactory. This spray has been tested for the past four years and it has apparently been satisfactory when properly applied.

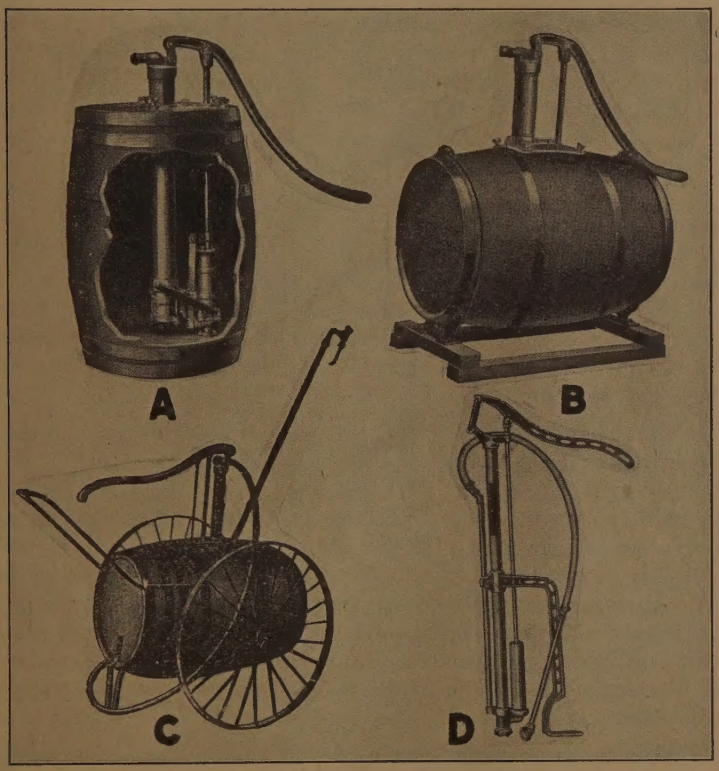

Figure 2.—A, B, and C. Types of barrel sprayers that may be used in spraying seed beds if equipped with pumps that will generate sufficient pressure. D. Bucket pump.

1. Materials required to make 50 gallons of spray solution: To make 50 gallons of spray, use one-half pound of cuprous oxide (red copper oxide), one quart of Lethane spreader, one-half gallon of cottonseed oil, and enough water to make 50 gallons.

2. Method of preparing the mixture: Too much care can not be exercised in preparing the spray mixture because the spray is somewhat difficult to prepare properly; and if it is not properly prepared, it will not only fail to control blue mold but may injure the plants. In mixing the spray it is necessary to emulsify the oil thoroughly and to get the copper oxide into a water suspension. The procedure can be readily illustrated by assuming that a 50-gallon sprayer is to be filled. First fill the spray tank ⅔ full of water. Then place ½ pound of red copper oxide in a bucket, measure out 1 quart of Lethane spreader and add a small portion of it to the copper oxide powder in the bucket. This mixture is then stirred into a thin paste. Pour the remainder of the Lethane spreader into another bucket and add ½ gallon of cottonseed oil and about 1½ gallons of water. Stir the mixture and then pump it into another bucket, using an inexpensive bucket pump or sprayer (Fig. 2, D) with nozzle attached to produce an emulsion. This process should be repeated until the oil is completely emulsified, after which it is poured into the spray tank. When the oil is properly emulsified it will be milky white in appearance and no oil droplets will collect on the surface of the solution after the emulsion is added to the water in the spray tank. Now take the bucket containing the copper oxide paste, add a little water, stir into a thin paste, finish filling the bucket with water, and pour the entire contents into the spray tank, which already contains the cottonseed oil emulsion. Then add enough water to bring the total volume up to 50 gallons. Smaller amounts of the spray can be prepared in the same manner by simply reducing the quantity of materials used in the proper proportion.

3. Method of applying the spray: Prepare only enough spray solution for one application and use it immediately. A good sprayer is essential for the proper application of the spray. A small power sprayer (Fig. 1, B) is an ideal outfit for this purpose but since it might be impossible to obtain such an outfit, a barrel or bucket sprayer (Fig. 2) that will maintain a pressure of 125 to 150 pounds, may be substituted. Apply the spray through a nozzle that produces a fine mist or fog, and apply enough spray to wet the leaves of the plants. Spray the underside as well as the top of the leaves but do not drench the soil. About 2½ gallons of spray will cover 100 square yards of bed if the plants are small, but large plants require from 5 to 7 gallons per 100 square yards for each application.

4. When to spray: Begin spraying before infection appears in the seed bed and spray twice a week thereafter until danger of blue mold is over or until the plants are ready to be set. If rain falls on the plants before the

spray is dry, another application should be made as soon as possible. A total of 8 to 12 applications should be used, at least 3 or 4 of which should be made before the disease attack becomes general. Rapidly growing plants must be sprayed twice a week to afford proper protection. Apply the spray only when the plants are dry and after the seed-bed cover has been removed. Small plants with their leaves still flat on the ground may be sprayed through the cover, but this should not be attempted after the plants are larger. Spraying through cloth is only possible, however, *when the cover is well above the plants.*

The principal advantage of spraying over the fumigation method is that it is less expensive, the cost of spraying, not counting cost of sprayer, being three or four dollars per 100 square yards of seed bed.

Too much emphasis cannot be placed on the importance of using adequate spray equipment. The barrel type of spray machine with a pump capable of maintaining a pressure of 125 to 200 pounds should prove satisfactory for spraying seed beds. The outfit should be equipped with at least 50 feet of ⅜-inch hose, a 6-foot rod, and a nozzle that will break the spray up into a fine mist. Constant agitation of the spray solution should be maintained while spraying to keep the materials from settling out.

Spraying apparently will not completely prevent blue mold infection if the weather remains cool and rainy over a long period of time. Such weather in addition to being very favorable for blue-mold infection is unfavorable for spraying and the rains wash off the spray material. Sprayed plants, however, recover much more rapidly than unsprayed plants after a disease attack. Affected plants, whether sprayed or unsprayed, should not be transplanted until they have sufficiently recovered.

Note: Cuprous oxide (red oxide of copper) is a standard chemical manufactured and sold by several chemical concerns. The material used for spraying tobacco seed beds should contain about 92 percent cuprous oxide, be red in color, and finely divided. Only fresh material should be used. The presence of dark lumps is a sign of deterioration. The Lethane spreader used in the experimental work was prepared and sold by Rohm and Haas Company, 222 West Washington Square, Philadelphia, Pa. Cuprous oxide is also manufactured and sold by this company. Cottonseed oil may be purchased as such, or under the trade name of Wesson Oil.

The fumigation method.—As the name indicates, the fumigation method involves the use of fumes or vapors which penetrate all parts of the seed bed. Obviously the method is fundamentally precise because the fumes come in contact with the entire exposed surface of the plants. Australian workers were the first to use volatile materials such as benzol and toluol for the control of tobacco blue mold; but because of the difference in climate and cultural practices in Australia and the United States, it was necessary to modify the Australian method of making the treatment before it could be used under our conditions.

Results of tests in 1936 and 1937 showed that complete control of blue mold could be obtained with this method even after the disease appeared in the seed bed. Hence, even though the fumigation method is expensive and rather cumbersome to apply it apparently has sufficient merit to warrant a detailed description. It should be clearly understood, however, that while complete control of blue mold has been obtained with benzol fumigation and while it may appear to be the solution of the blue-mold control problem, exten-

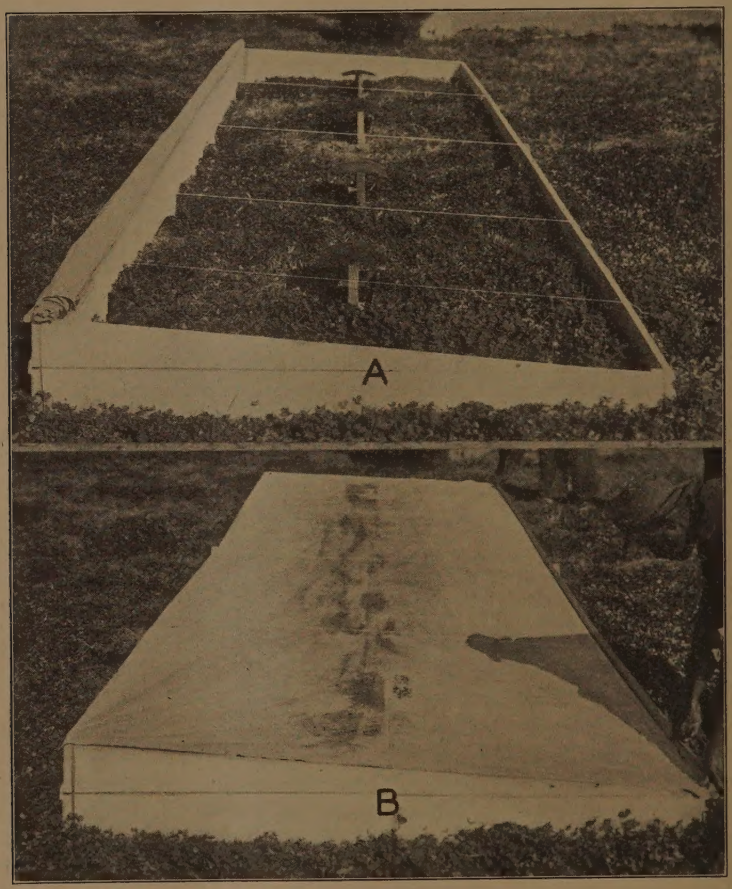

Figure 3.—Type of seed bed to use for fumigation. A. Seed bed with cover rolled back to show the arrangement of the benzol evaporators down the center of the bed. B. Seed bed with special cover in place. Note the tight condition of the bed frame. The plants in A are clover and not tobacco.

sive research remains to be done before definite recommendations can be made for its unrestricted use.

Procedure for benzol fumigation:

1. Beds of various dimensions may be used, but those 6 or 12 feet wide and 24 or 30 feet long appear best suited to the mechanics of fumigation. Furthermore, beds of these dimensions afford protection against trampling the plants.

2. In order for the benzol vapors to be effective against blue mold, the beds must be tightly framed (Fig. 3, A and B) to prevent the escape of the vapors. The frames should be 6 to 8 inches high and tightly banked with soil at all possible openings.

3. Place the empty benzol vaporizers (Fig. 3, A) in position after sowing the seed in order to prevent unnecessary injury to plants later and then cover the bed with a good tight tobacco seed-bed canvas.

4. Examine the beds daily after the plants come up in order to determine the first appearance of blue mold. Actual fumigation apparently need not begin until blue mold is present in the locality or in the bed, because if the fumigation is properly conducted, it promptly destroys the blue-mold fungus.

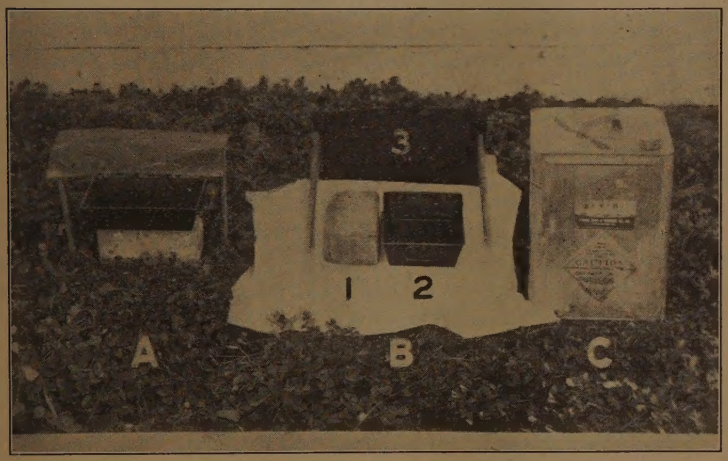

Figure 4.—Type of benzol evaporator that can be easily assembled. A. Evaporator assembled and in position in the seed bed. B. Evaporator showing its several parts — 1, an ordinary brick; 2, a bake pan; and 3, a piece of tin roofing with a stake nailed to each end. The brick supports the bake pan in which the benzol and oil are placed. The piece of tin serves as a roof over the bake pan and as a support for the seed-bed cover. C. An empty benzol can.

Figure 4, B-2 shows the proper size of evaporating pans to use in a bed 6 by 30 feet. Pans and beds of other sizes may be used but the area of bed fumigated by one pan must be approximately 72 times that of the evaporating surface area of the pan. If smaller pans are used, blue mold may not be controlled; whereas if larger ones are used, the plants may be killed on hot nights because there may be too much vapor produced.

For the pans illustrated in Figure 4, B, use 1 pint of old engine oil, or an equal amount of lubricating oil, and 3 or 3½ ounces of benzol. The purpose of the engine oil is merely to retard the rate of evaporation of the benzol so that the proper quantity of benzol vapor will be present in the bed just before sunrise when it is apparently most needed to prevent blue-mold infection. The oil may be used repeatedly and need not be removed from the pans.

After pouring the oil and benzol into the pans, place the pans on supports under suitable covers (Fig. 4, B-3) and replace the ordinary seed-bed cover with one of heavier texture (Fig. 3, B). Unbleached muslin with about 50 to 60 threads per inch should prove satisfactory. A cloth of this texture allows rain to enter the bed but prevents escape of the benzol vapor when wet with dew or rain. After sunrise, the cover should be folded back completely off the bed in such a manner that it will dry. The cloth may rot if rolled tightly and left in contact with the soil.

From one-half to two-thirds of a gallon of benzol is required each night for every 100 square yards of bed area. Since the treatments may be withheld until blue mold is present in the bed and since they may be discontinued during hot nights or as soon as the plants are ready to be set in the field, the number of treatments required will vary with the season and the location of the bed.

Cautions.—*Benzol* is another name for *benzene*, a by-product of the coal and iron industry. It is an entirely different chemical from *benzine*, a by-product of the petroleum industry. *Benzine* must not be used as a substitute for *benzene* in the fumigation of tobacco seed beds.

Benzol is a highly inflammable and poisonous chemical. It must not be handled near lighted matches, cigarettes, etc. It must not be handled in closed rooms, spilled on the hands or plants, stored in warm places, or allowed to stand in the sun in closed containers.

2. Suggestions for Control of Tobacco Flea Beetle

By W. J. Schoene, *Entomologist*
and
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The tobacco flea beetle [1] is an old insect pest which occurs on growing tobacco and does more or less damage each year. It is the only one of the major insect pests of tobacco that attacks the plants in the seed bed and also throughout the growing season in the field. Usually the most evident injury is done in the seed beds. The feeding by the beetles and the larvae greatly stunts the plants and oftentimes kills young plants. The yield and quality of the crop, especially of late tobacco, may be much lowered. In the spring of 1937, this insect was unusually abundant in central southside Virginia and the injury to plants in many seed beds and on transplants was severe to the tops, roots, and stems. In this area, the season of 1936 was rather dry and apparently favorable for the beetles to build up a large population. The winter of 1936-37 was mild and it is believed that most of the overwintering beetles survived and consequently large numbers attacked the seed beds early in the season.

The tobacco flea beetle is too well known to tobacco growers to need description. The adult beetle is about the size of a common pin head or about one-twelfth of an inch long. Their readiness to hop has suggested several common names as "flea bug," "tobacco flea," etc. Each season they are usually observed first in the seed bed, where they oftentimes occur in large numbers. On first appearance they have a ravenous appetite and cause injury to the plant out of proportion to their size. The beetles pass the winter under leaves and trash in fence rows around the edges of tobacco fields, and especially under leaves in the edge of the woods. They begin to leave their winter hiding places during the latter part of March in search of food, and they fly or hop across the country until the seed bed is found, where they feed mostly on the upper surface of the leaf. After feeding for some time, they begin to lay eggs around the base of plants and the larvae that hatch from these eggs feed on the roots of the young tobacco plants. A new generation of beetles appears about July 1. There are several generations during the year. The adults feed throughout the season on the growing tobacco in the field, often causing the lower leaves to have a ragged shot-hole appearance. After the tobacco is harvested the adult flea beetles feed on the suckers left in the field and also on certain wild host plants especially the horse nettle. They remain on the plants, feeding during the warmer part of the day, until cold weather when they leave the tobacco fields to hide under leaves during the winter. In the fall there is a fairly definite migration of insects from the tobacco fields to the woods and a return migration to the fields in the spring.

[1] Epitrix parvula.

Type of Injury

From the grower's standpoint, the principal damage in past years by the flea beetle has been due to the overwintered beetles feeding in the seed beds. The adults continue to feed all summer but the small holes are overlooked. In most seasons the beetles appear when the tobacco plants in the seed bed are very small with the result that the developing cotyledons of many plants are destroyed before the tobacco grower is aware of their presence. It is not unusual to receive frantic calls from farmers for information when the beetles

Figure 5.—Tobacco plant seriously injured by the tobacco flea beetle. The lower leaf was almost entirely consumed and was brown in color. This was the condition of many plants that had been set in the tobacco fields.

arrive early. If the insects do not reach the seed beds until the plants are about half large enough to transplant, the injury resulting from their feeding is not so serious.

The Outbreak During 1937

During 1937 the injury by the flea beetle was of a different type from that heretofore observed. This was especially true in Pittsylvania County, Virginia, and in the Piedmont section in North Carolina. There was severe feeding on the foliage (Fig. 5), and the upper part of a few plants was almost consumed by the beetles, but most of the plants developed to sufficient size for transplanting in spite of this injury. The stems and roots of the tobacco plants were badly infested by the larva of the flea beetle at the time they were drawn from the seed bed and when these plants were set in the field they failed to grow as a result of the injury to both tops and roots and there was a high

Figure 6.—Tobacco plant injured by flea beetle. The outer portions of the leaves were brown. It will be noted that the root on this plant is very small. This was caused by feeding of the larvae of the flea beetle.

percentage of plants that died (Fig. 6). Thus, in 1937, the flea beetle and blue mold together necessitated replanting the fields several times. This replanting continued for about six weeks and even then there was only a partial stand in some fields. The total net loss was very severe.

Many examinations of tobacco fields were made during the fall of 1937 to study the feeding habits of the adult flea beetles at this season of the year. Beetles were found in considerable numbers feeding on the tobacco stems and leaves during the month of September and as late as October 20. A leaf or stalk close to the ground was generally preferred. Wilted leaves were especially relished. In the warm part of the day the beetles clustered on the sunny side of the plant. The large numbers present at this season of the year indicate that this late fall feeding is very important in the development of this insect.

Control in Plant Beds

Arsenical treatment.—An excellent remedy for flea beetle is to apply a mixture of 1 part of Paris green with 5 parts of arsenate of lead at the rate of one-half pound per 100 square yards of seed bed. This poison will not burn or injure the plants and is effective in controlling the beetles. One application is usually sufficient, unless a rain falls a short time after the treatment, in which case the application must be repeated. The poison may be applied with a crank duster or bellows duster, or may be shaken though a cheesecloth bag. Care should be taken to prevent a spotty application since large deposits of this poison might burn the foliage of the plants.

Rotenone treatment.—During the past several years rotenone has been widely used. This is a satisfactory control for flea beetles attacking tobacco. It is a derris or cube dust containing 1 percent of rotenone. These dusts are obtained by mixing derris or cube powder with a form of clay. The following dosages of dust are recommended for each application: For seed beds, ½ pound per 100 square yards, applications to be repeated every 4 days until control is obtained.

Control in the Field

Damage to the newly-set plants may be prevented by the use of either of the above insecticides. Many growers follow the practice of dipping the plants in a mixture of arsenate of lead and water. For this purpose a pound of the poison to each 10 gallons of water should be used. Arsenate of lead is not recommended for field treatment after the plants have become established.

Severe infestations of the flea beetle can be held in check with rotenone dust. For newly-set plants, use 3 to 5 pounds per acre, repeating the application every 4 days until control is obtained. For the growing-tobacco crop, use 6 to 10 pounds per acre, depending on the size of the plants, repeating the application every 7 days until control is obtained.